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Title: "Remote Photoluminescence Surveyor"

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This is a program to measure the short- and long-lived UV-Visible pumped luminescence of many different abiotic and biotic materials under conditions that simulate extraterrestrial environments. The purpose is to provide a catalog of the fundamental data and demonstrate proof-of-concept for eventual development of novel, deployable instruments that will be capable of surveying (mapping) the distribution of organic and mineral matter on or slightly below the surface of normal and icy terrain over areas of some several hundred square meters. Mapping radiatively-pumped luminescence over large areas is a novel technique for planetary exploration and one that addresses the key objective of detecting organic matter.

This award presented an opportunity for us to focus some of our NAI Astrobiology Team activities and the Ames Astrochemistry Laboratory capabilities to support, more directly than ever before, NASA's space missions and exploration program. Our first year's activities after receipt of the award were directed to this end. The first several months focused on moving the UV-Visible-Near IR (UV-Vis-NIR) experimental apparatus to a larger laboratory. This move permits complete accessibility as well as provides the additional space needed to construct and test small instrument spacecraft prototypes that could be calibrated with our research grade equipment set-up. Prior to this, the set-up, which is roughly 6 feet across, was squeezed into a long rectangular darkroom that was 8.5 feet wide and 26 feet long. It was very crowded and the optical pathways crammed on our 4'x4' optical bench were becoming labyrinthine. Needless to say, this is not the way to start a new, expanding program.

Thanks to visionary Ames Division and Branch management, a year earlier, we had been given a room to expand the Astrochemistry Laboratory's capabilities in hopes of initiating new experimental programs that more directly support NASA missions than previously possible. This new room was the obvious home for the UV-Vis-NIR set up and so, using other funds, we upgraded the new space into a modern laboratory, installed industrial grade black curtains that convert half of the lab into a dark-room and moved the UV-Vis-NIR set-up in place. The instrument now occupies a rectangular space that is 10 feet across and 30 feet long. The extra width allows instrumental access from all sides while the length provides room for expansion and the construction of prototype test beds. The optical table was also doubled in size from 4' x 4' to 4' x 8'. On top of this, several months ago we had the very good fortune to have Dr. Nathan Bramall* join this project. Nathan is now part of our Ames Astrobiology Team proposal in which Dave DesMarais is PI. Nathan brings experience in studying the luminescence from biomaterials as well as field experience in developing instrumentation to search for bioluminescent materials in snow fields and glaciers. Lastly, we decided to use a portion of the NAI DDF funds to upgrade some of the older pieces of optical equipment which included sources, spectrometers and gratings dating back to the late 1980's and early 1990's as well as data logging programs which are now completely outdated. The new equipment and programs will

allow us to measure very fast (sub nano-second) radiative lifetimes as well, a capability that separates us from most other laboratories studying luminescence aimed toward remote sample analysis.

Thanks to receiving this NAI DDF grant, we have been able to put together a group of experimentalists and instrumental capabilities that are unique in this business. As a direct result of this, we are now part of Dr. Pascale Ehrenfreund's successful NAI DDF project, "Evolution of Organic Matter in Space: UV-Vis Spectroscopy Investigation on Nanosatellites" and we are part of OREO, the Ames Astrobiology Small Satellite. OREO is planned to investigate the degradation of a variety of organic molecules by solar radiation in the space environment by monitoring their UV-Vis absorption and luminescent properties at regular intervals. Our role in both of these programs will be to help determine the measurements to be made, carry out preflight spectroscopic measurements on the samples to be flown thereby calibrating the experiment, helping determine experimental flight protocols, and carry out spectroscopic measurements on a duplicate set of samples to compare with the incoming data from the flight experiment. In the course of this work we will be building the catalog of luminescent properties which is the ultimate goal of our NAI DDF grant. We anticipate that these experiments will be starting in earnest over the next few months.

As part of our program to monitor the luminescence of biomolecules under different conditions, we also intend to use the UV-Vis-NIR set up to perform important experiments of direct astrobiological interest. For example, we plan to verify or refute the claim that intracellular water remains unfrozen down to -60 C (Ostroumov and Siegert, *Adv. Space Res.*, 12: 79-86,1996)—a result that has dramatic implications for life at low temperatures. We will do this by using tryptophan (Trp) as a fluorometric probe and exploit its sensitivity to changes in the dynamic dielectric properties of the solvent in which it is dissolved. By studying microorganisms at low temperatures, we expect that once the intracellular water freezes, we will see the emission spectrum of Trp-dominated protein fluorescence shift towards shorter wavelengths due to the change in the fluorescence emission spectra of hydrophilic residues caused by the crystallization of surrounding water. We will be working with microorganisms immured in permafrost (*in-situ*), samples of which we have recently obtained from Keith Echelmeyer (Geophysical Institute, University of Alaska, Fairbanks). By using phsychrophilic microorganisms *in-situ*, we expect that our results will be highly representative of the limits of life at low temperatures. We plan to start this work in the very near future and, while predicting the course that research will follow is risky, we anticipate that we will have results that can be presented at scientific meetings in about six months.

* Nathan Bramall is a NASA Postdoctoral Fellow working with Carol Stoker on mission related work. His doctoral work involved measuring in-vivo luminescence from different biomaterials and rock/minerals, and field work in Antarctica. He came to Ames to explore new instrument concepts and develop prototypes for deployment.